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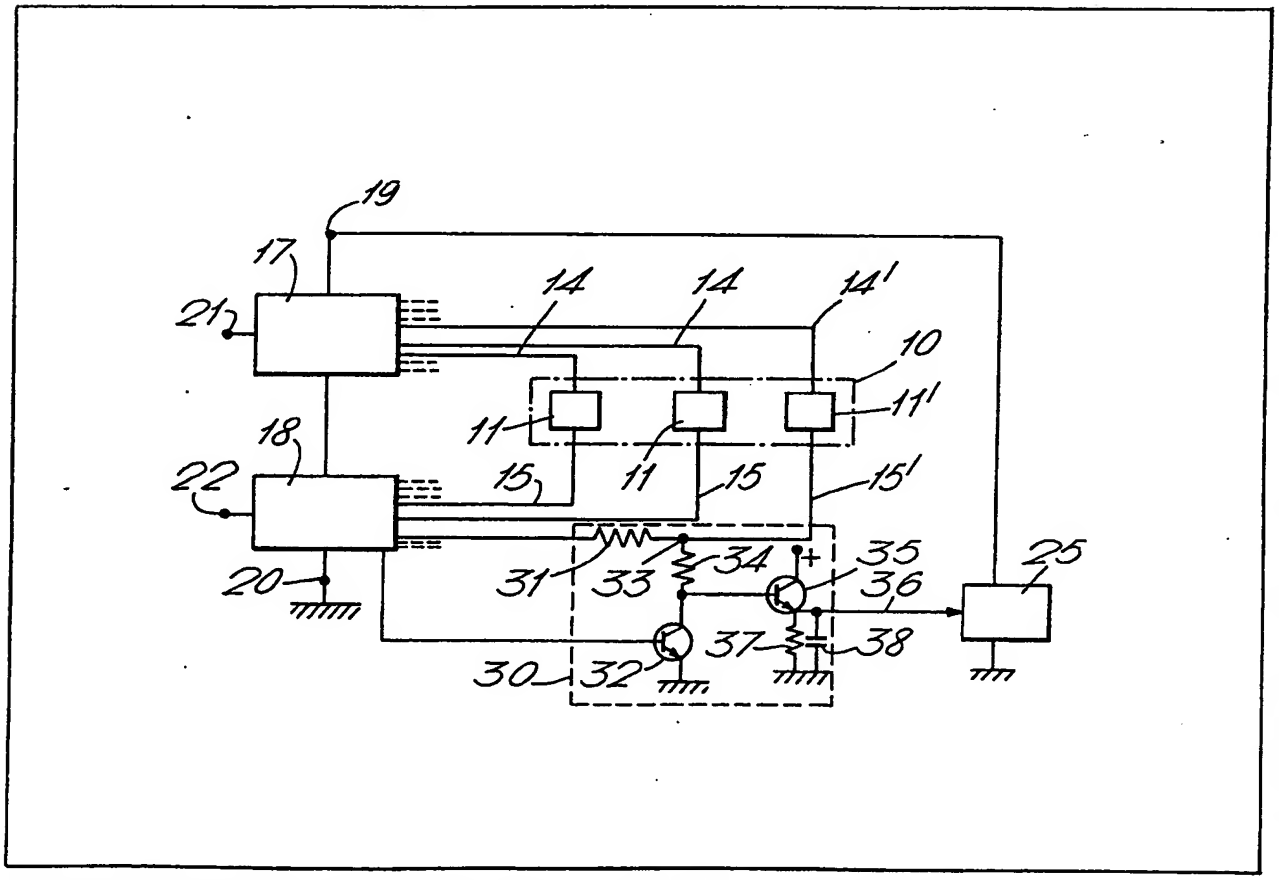
(54) Electroluminescent display device

(57) A d.c. electroluminescent display device having a plurality of individual display segments (11), each selectively energisable by switches 21, 22 to emit light by the application thereacross of a common supply voltage from a power supply (25) through driving circuits (17 and 18), has means (30) which monitors an electrical characteristic, e.g. current of a representative one (11') of the display segments and controls the variable power supply (25) to vary the common supply voltage to all segments in accordance therewith so as, for example, to counteract the effects of ageing by stabilizing the wattage and thus the brightness.



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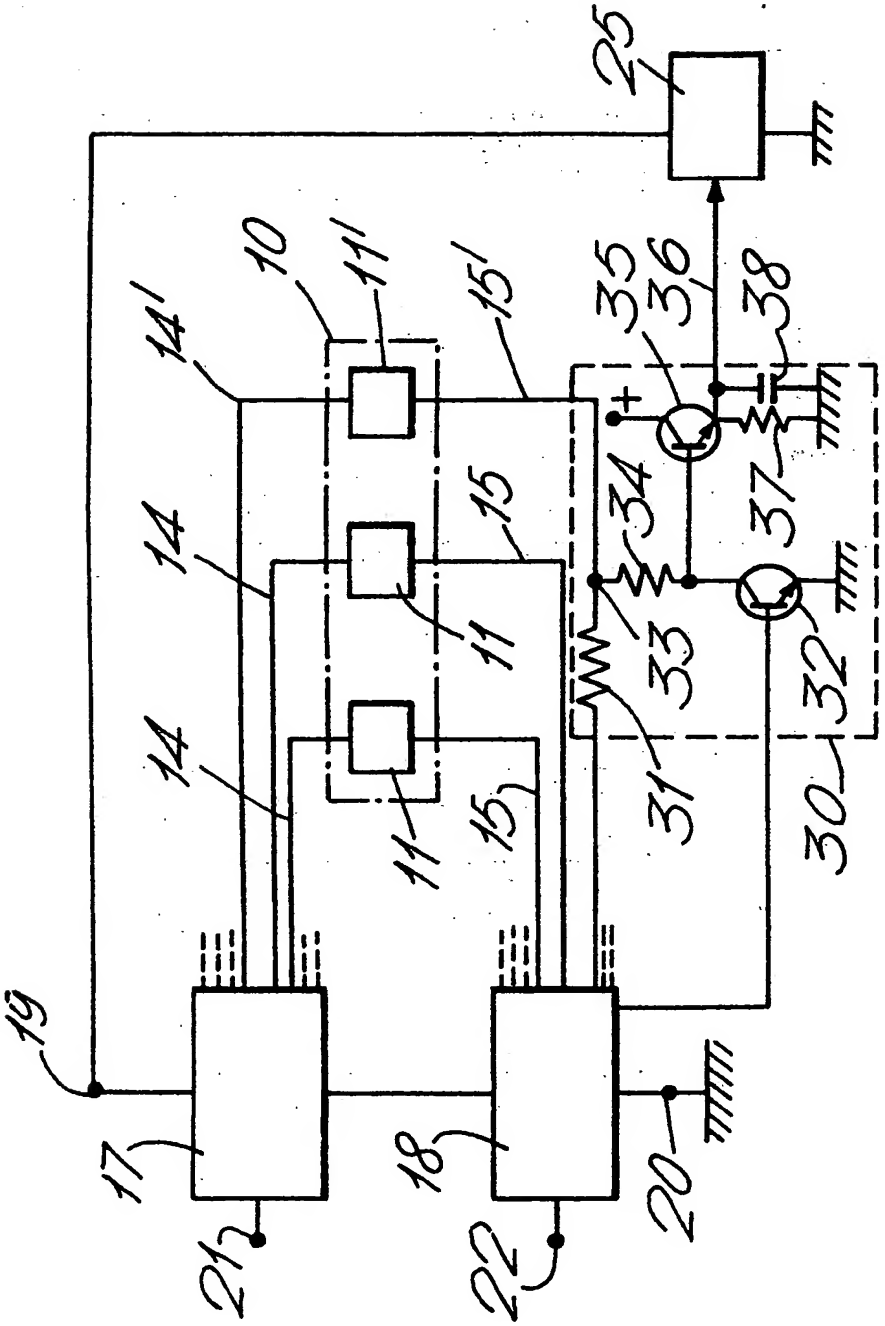
The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.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SPECIFICATION

Electroluminescent display devices

This invention relates to electroluminescent display devices. The invention is particularly concerned with a direct current electroluminescent display device comprising a direct current electroluminescent panel having a plurality of independently operable display segments or elements, and means for operating the panel.

Direct current electroluminescent display panels are generally well known and comprise, as, for example, is described in the UK Patent Specification No. 1,300,548, a suitable electroluminescent phosphor material, for example a zinc sulphide phosphor material, sandwiched between two sets of electrodes, one of which is carried on a transparent substrate. A voltage applied across the two electrodes causes the phosphor material to luminesce where upon light produced thereby is transmitted through the transparent substrate to provide a desired display. By appropriate configuration of the two sets of electrodes, the display device may be used to provide a multi-digit alpha-numeric display or multi-element display such as for example, a bar-graph type display. Such a display device may conveniently be driven using multiplexing techniques.

The brightness of a direct current electroluminescent display device is dependent upon, among other things, the magnitude of the electrical current passing through the phosphor material. However, over a period of time, the electro-optical properties of the phosphor material tend to change and consequently affect the light-emission capabilities of the display panel. More particularly, the electrical resistance of the phosphor material is found to increase with age so that, if a constant drive voltage is applied across the electrodes, the electrical current passing therethrough, and the brightness of the emitted light, decrease.

In attempts to alleviate the problem resulting from changes in the electro-optical characteristics of the electroluminescent panel during its lifetime, it has been proposed that a resistor of relatively small value in comparison to the panel resistance be connected in series with each of the separate display segments or elements of the electroluminescent panel and a constant voltage source, so that when the resistance of each display segment or element of the panel increases with age the voltage drop across the series resistor decreases and that across the panel increases. In this way the decrease in electrical power consumed by the panel is less and the decrease in intensity of luminescence is less than would be the case if the series resistor were not present.

Such an arrangement has been found to work reasonably satisfactorily as regards maintenance of light output. However, in a multi-segment display device, for example an alpha-numeric or bar-graph type display, where each individual element or segment of the display is driven independently, providing a separate compensating resistor for each segment is both expensive and inconvenient. Furthermore, such series resistors introduce time constants, (because of the self-capacitance of the display device) which adversely affect operation when the device is energised by relatively short duration electric pulses, as will usually be the case in practice.

It also has been known to use respective active electrical devices connected between a common constant voltage source of the display device and each of the display segments of the electroluminescent panel which respond to a variation in the electrical characteristics of their associated display segment to vary the electrical current through that segment in accordance with those variations.

Again however the fabrication of a multi-segment display device using a respective active electrical device of this form for each individual segment of the panel is both expensive and inconvenient.

It is an object of the present invention to provide an improved electroluminescent display device of the multi-segment type.

According to one aspect of the present invention, there is provided an electroluminescent display device comprising an electroluminescent panel having a plurality of individual display segments each of which is independently energisable by the selective application thereacross of a common supply voltage to emit light, and means for monitoring an electrical characteristic of a representative one of the plurality of display segments and varying the common supply voltage in accordance therewith so as thereby to control electrical power through the plurality of display segments in a manner which tends to maintain brightness of the display segments substantially constant.

The power control means may be arranged to monitor electrical current flow through the one display segment, and preferably during energisation of that segment by application of the common supply voltage thereacross. In this case the power control means may be operable to vary the magnitude of the common supply voltage in accordance with variations in the electrical current flow through the one display segment so as to tend to maintain substantially constant electrical power through that display segment. For example the power control means may respond to a decrease in electrical current flow through the one display segment resulting from an increase in the internal resistance of that segment to increase the common supply voltage. The power control means may include signal generation means for generating a signal in dependence upon a predetermined change in the electrical characteristic of the one display segment, and variable power supply means for producing the common supply voltage which is responsive to that signal to vary the magnitude of the common

supply voltage.

The display segments, which may collectively form an alpha-numeric or bar-graph type display, may comprise a layer of electroluminescent phosphor material sandwiched between front and back electrodes, one of which electrodes preferably being carried on a substrate. The electroluminescent panel may comprise a unitary structure, in which case the plurality of display segments may comprise discrete regions of a common layer of electroluminescent phosphor material that are defined by respective front and back electrodes.

The display device may include driving circuitry operable to supply selectively the common supply voltage across the front and back electrodes of the electroluminescent panel. Preferably, the driving circuitry is arranged to operate in multiplexed fashion.

The power control means may be arranged to monitor electrical current flow between, for example, the back electrode of the one display segment and a respective output of the driving circuitry.

One form of multi-segment electroluminescent display device in accordance with the present invention will now be described, by way of example, with reference to the accompanying drawing which shows schematically the electrical circuit configuration of the display device.

Referring to the figure, the display device includes a D.C. electroluminescent display panel, generally indicated at 10, having a plurality of independently — operable display segments 11. For simplicity only three such display segments are shown in the figure. It should be understood that the actual number of display segments employed would depend on the display requirements for the device. The display segments may be arranged in any suitable manner to provide a desired display pattern, for example in a linear fashion for a bar-graph type display or in seven-bar digit configuration for an alpha-numeric type display.

The basic construction of such electroluminescent panels is well known in the art and therefore will only be described here briefly. The electroluminescent panel is a unitary structure and comprises a continuous layer of D.C. electroluminescent phosphor material, sandwiched between a sheet of transparent, insulating material, such as glass, carrying a front electrode configuration in electrical contact with the electroluminescent phosphor material, and a conductive layer of, for example, aluminium constituting the back electrode.

The front electrode configuration comprises a pattern of electrically conductive tin-oxide electrodes defining discrete segments, or regions, of the common phosphor layer of the display. The back electrode is divided into electrically-isolated areas to provide a second set of electrodes arranged such that each surface of any area of this electroluminescent material which is to be energised is in electrical contact with a respective one of the tin oxide front electrodes and a respective one of the aluminium back electrodes. Thus any particular segment of the display, as defined by its respective front and back electrodes, can be made to emit light through the glass substrate by selectively energising the appropriate back and front electrodes.

The segments of the display, or more particularly their respective front and back electrodes, are conveniently energised using multiplexing techniques. In this respect, and as shown in the figure, the front and back electrodes of each display segment 11 are electrically connected through lines 14 and 15 to driving circuits 17 and 18 respectively that are connected to a source of positive potential and earth at terminals 19 and 20, and which are arranged to operate in accordance with signals at their inputs 21 and 22 so as to energise appropriate ones of the lines 14 and 15 in multiplexed fashion and cause associated ones of the display segments 11 to emit light.

Thus, although each of the display segments 11 of the display panel is individually energisable, the driving circuits 17 and 18 operate to supply a common energising voltage across particular ones of the segments 11 via their respective lines 14 and 15 in a multiplexed fashion so as to cause those segments collectively to display, in the case of an alpha-numeric type display for example, a character or characters, or, the case of a bar-graph for example, a band of light generated by sequential energisation of adjacent ones of the linear array of segments.

The source of supply voltage for the front and back electrode driving circuits 17 and 18 is common to all display segments 11 and is derived from a power supply unit 25. The voltage generated by the power supply unit is typically in the order of 100 volts. As will be described hereinafter however, the power supply unit 25 is capable of providing a variable output voltage. In a situation where, for example, the display device is to be used in a vehicle, the power supply unit 25 may be powered from the vehicle's 12 volt power supply system and in this case would include inverting, rectifying and smoothing circuitry for raising the voltage output to a level sufficient to cause luminescence in the electroluminescent panel 10. The output from the power supply unit 25 to the electrode driving circuits 17 and 18 is preferably in the form of uni-directional pulses, the use of which is known to extend the lift of electroluminescent panels, although continuous voltage can also be used.

As has been described previously, the electro-optical characteristics of an electroluminescent panel, and more especially its electrical resistance, tends to change over a period of time with a consequential reduction in the brightness level of the light emitted therefrom. The present invention seeks to overcome this problem by providing means for monitoring an electrical characteristic of a typical and representative one of the display segments 11 of the panel 10 and varying the

power supplied to the front and back electrode driving circuits 17 and 18 from the power supply unit 25 in response to changes in that monitored characteristic. More particularly, the display device includes means for monitoring the electrical current flow through a representative one of the display segments during energisation of that segment and increasing the effective common voltage, that is the amplitude of the unidirectional pulses, applied to all the display segments of the electroluminescent panel in accordance with increases in the electrical resistance of the panel during its life so as to increase correspondingly the electrical power through all the display segments thereby tending to maintain a substantially constant level of brightness of the light emission from the display segments of the electroluminescent panel, or at least to counteract to some extent the decrease in brightness which would otherwise normally be experienced.

In this respect, the display device includes a current monitoring circuit, generally designated at 30, connected to one, 15′, of the plurality of lines 15 from the back-electrode driving circuit 18 to the display segments 11. As the display segments 11 comprise discrete areas of a unitary layer of electroluminescent phosphor material formed as a continuous deposition, it can be assumed that the behaviour of one of the display segments 11 is typical of all other display segments in the panel and that variations in the electro-optical characteristics of that one display segment correspond substantially with variations in the other segments of the panel. Thus variations in the operational conditions existing on the line 15′, associated with the particular display segment 11′, may be regarded as being representative and typical of similar variations in operational conditions existing on the other lines 15.

The current monitoring circuit 30 includes a resistance 31 connected in series in the line 15′ between the back-electrode of the segment 11′ and the respective output from the back-electrode driving circuit 18. The value of the resistance 31 is chosen to be relatively small so that the voltage drop which occurs thereacross is insufficient in comparison to the display segment energising voltage to cause any appreciable difference in the brightness level of the segment 11′ associated with the line 15′.

The current monitoring circuit 30 further includes a transistor 32 whose collector is coupled through a resistance 34 to a point 33 on the line 15′ intermediate the resistance 31 and the display segment 11′, and whose emitter is earthed. The base of transistor 32 is connected to a further output from the back electrode driving circuit 18 associated with the output therefrom to the line 15′ so that the transistor 32 is switched in accordance with energisation of the display segment 11′, whereby operation of the current monitoring circuit 30 is synchronised with energisation of that display segment as determined by the drive circuit 18.

The point 33 is also connected, via series resistance 34, to the base of a transistor 35 which acts as a current amplifier. The collector of transistor 35 is coupled to a source of positive potential, and its emitter is connected through a lead 36 an input of the variable power supply unit 25 and through a resistance 37 and capacitor 38 in parallel to earth.

The front and back electrode driving circuits 17 and 18 of the display device are arranged to operate such that, during operation of the device, the voltage on both electrodes of any display segment which is not required to emit light is held at, say 50 volts. When energisation of a particular display segment 11 is required, as determined by signals at inputs 21 and 22, the drive circuits 17 and 18 operate such that their output to the lines 14 and 15 associated with display segments 11 approach 100 volts and earth respectively. In this way, an effective voltage of 100 volts is applied across the display segment 11 causing it to luminesce and emit light.

During typical operations of the display device, the particular display segment 11′ to which the current monitoring circuit 30 is connected will periodically be energised. Upon each such energisation, the transistor 32 is switched so as to render the circuit 30 operative. The voltage existing at the point 33 during energisation of the display segment 11′, as determined by the supply voltage, the value of the resistance 31 and the internal resistance of the display segment 11′, and indicative of the current flowing through resistance 31 and segment 11′, is amplified by transistor 35 whose output is smoothed and stored in the capacitor 38. Thus a D.C. voltage signal is produced on the lead 36 to the input of the variable power supply unit 25 which is substantially proportional to, and varies in accordance with, the voltage at point 33 on the line 15′. The variable power supply unit 25 is arranged to operate automatically to raise, lower, or maintain constant the common supply voltage supplied to the driving circuits 17 and 18 in dependence upon the value of the voltage signal along the lead 36.

The initial, desired level of the electrical current flowing through the display segment 11′ during its energisation is predetermined and the value of the resistance 31 chosen accordingly. Should the internal resistance of the display segment 11′ increase over a period of time of operating the panel, for example through ageing, the electrical current through the segment 11′ decreases whereupon the circuit 30 responds to the resultant change in voltage sensed at the point 33 on line 15′ to increase the effective voltage applied, across all the segments 11, up to a maximum say of 120 volts to avoid damaging the panel, thereby tending to maintain the predetermined electrical current level through the segments. Conversely, the current monitoring circuit 30 responds to a decrease in the internal resistance of the display segment 11′ by correspondingly decreasing the supply voltage.

Hence the current monitoring circuit 30 and the

variable power supply unit 25 operate in a manner tending to compensate for any variations which may occur in the electrical characteristics of the electroluminescent phosphor material of the display panel by controlling the common supply voltage applied across the display segments of the panel so as automatically to maintain a near constant electrical current through all the display segments, and therefore a substantially constant level of brightness of the light emitted by the display segments. Such an arrangement is both relatively simple and cheap to manufacture since it avoids the necessity of providing either respective resistances or active electrical devices for each of the plurality of display segments in the device.

To a certain extent, the lifetime of an electroluminescent display device is dependent upon the temperature at which it is operated, the higher the operating temperature, the shorter the lifetime of the device. By controlling the power to the display segments in the aforementioned manner, the operating temperature of the device, proportional to the power consumed, is also controllable.

CLAIMS

1. An electroluminescent display device comprising an electroluminescent display device comprising an electroluminescent panel having a plurality of individual display segments each of which is independently energisable by the selective application thereacross of a common supply voltage to emit light, and means for monitoring an electrical characteristic of a representative one of the plurality of display segments and varying the common supply voltage in accordance therewith so as thereby to control electrical power through the plurality of display segments in a manner which tends to maintain brightness of the display segments substantially constant.

2. An electroluminescent display device according to Claim 1, wherein the power control means is arranged to monitor electrical current flow through the one display segment.

3. An electroluminescent display device according to Claim 2, wherein the power control means is arranged to monitor electrical current flow through the one display segment during energisation thereof by application of said common supply voltage thereacross.

4. An electroluminescent display device according to Claim 2 or Claim 3, wherein the power control means is operable to vary the magnitude of said common supply voltage in accordance with variations in the electrical current flow through the one display segment so as to tend to maintain substantially constant electrical power through that display segment.

5. An electroluminescent display device according to any one of the preceding claims, wherein the power control means includes signal generation means for generating a signal in dependence upon a predetermined change in the electrical characteristic of the one display segment, and variable power supply means for producing said common supply voltage which is responsive to that signal to vary the magnitude of the common supply voltage.

6. An electroluminescent display device according to any one of the preceding claims, wherein the display segments comprise a layer of electroluminescent phosphor material sandwiched between front and back electrodes.

7. An electroluminescent display device according to Claim 6, wherein one of said electrodes is carried on a substrate.

8. An electroluminescent display device according to Claim 6 or Claim 7, wherein the electroluminescent panel comprises a unitary structure and wherein the plurality of display segments comprise discrete regions of a common layer of electroluminescent phosphor material that are defined by respective front and back electrodes.

9. An electroluminescent display device according to any one of Claims 6 to 8, including driving circuitry operable to supply selectively said common supply voltage across the said front and back electrodes of the electroluminescent panel.

10. An electroluminescent display device according to Claim 9, wherein said driving circuitry is arranged to operate in multiplexed fashion.

11. An electroluminescent display device according to Claim 9 or Claim 10, and Claim 2, wherein said power control means is arranged to monitor electrical current flow between one of the electrodes of the said one display segment and a respective output of the driving circuitry.

12. An electroluminescent display device according to any one of Claims 9 to 11, wherein said power control means is coupled to the driving circuitry so as to operate in synchronism with energisation of the said one display segment.

13. An electroluminescent display device according to any one of the preceding claims, wherein the plurality of display segments collectively form an alpha-numeric or bar-graph display.

14. An electroluminescent display device substantially as hereinbefore described with reference to the accompanying drawing.

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